(12) UK Patent Application (19) GB (11) 2 356 022 (13) A

(43) Date of A Publication 09.05.2001

(21) Application No 9925976.4

(22) Date of Filing 02.11.1999

(71) Applicant(s)
Rolls-Royce plc
(Incorporated in the United Kingdom)
65 Buckingham Gate, LONDON, SW1E 6AT,
United Kingdom

(72) Inventor(s)
Nicholas Simon Andre Cristinacce

(74) Agent and/or Address for Service
Haseltine Lake & Co
Imperial House, 15-19 Kingsway, LONDON,
WC2B 6UD, United Kingdom

(51) INT CL[7]
F01D 9/04 11/00

(52) UK CL (Edition S)
F1T TFDE TFEA T109 T122 T131
U1S S1987

(56) Documents Cited
GB 2240822 A US 5374161 A

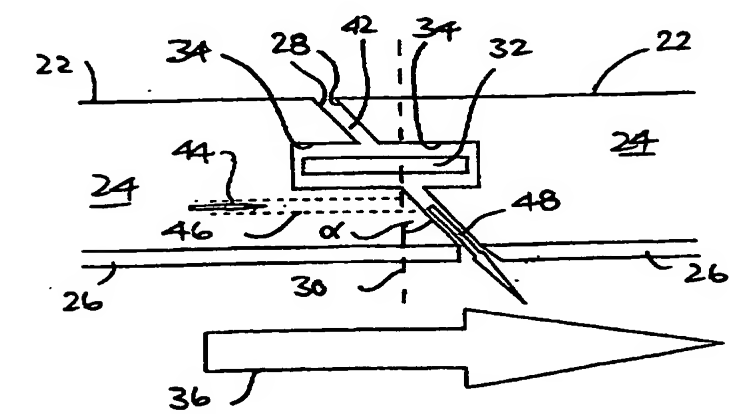
(58) Field of Search
UK CL (Edition R) F1T TFDE TFEA
INT CL[7] F01D 9/04 11/00 11/08 11/14 11/16 11/20 11/22 11/24 25/08 25/14 25/24 25/26
ONLINE: EPODOC,JAPIO,WPI

(54) Abstract Title

Cooling ends of a gas turbine engine liner

(57) A gas turbine engine has a turbine liner structure comprising a plurality of segments 22 disposed end-to end to form a ring surrounding a turbine (2, fig 1). A gap 42 defined between end faces 28 of each two adjacent liner segments 22 is inclined to a plane 30 which passes trough the gap 42 and contains the engine axis. The swirl component 36 of gas flow through the turbine draws air 48 through the gap 42 past a sealing strip 32. This air flow 48 may be enhanced by a cooling air feed 44. The air flow 48 enhances venting of the gap 42 and protects the upstream edge of each liner segment 22 from direct impingement of the hot gas flow, so reducing damage due to overheating of an alloy substrate 24 of each liner segment 22 and of any ceramic coating 26 provided on the substrate 24.

FIG. 3



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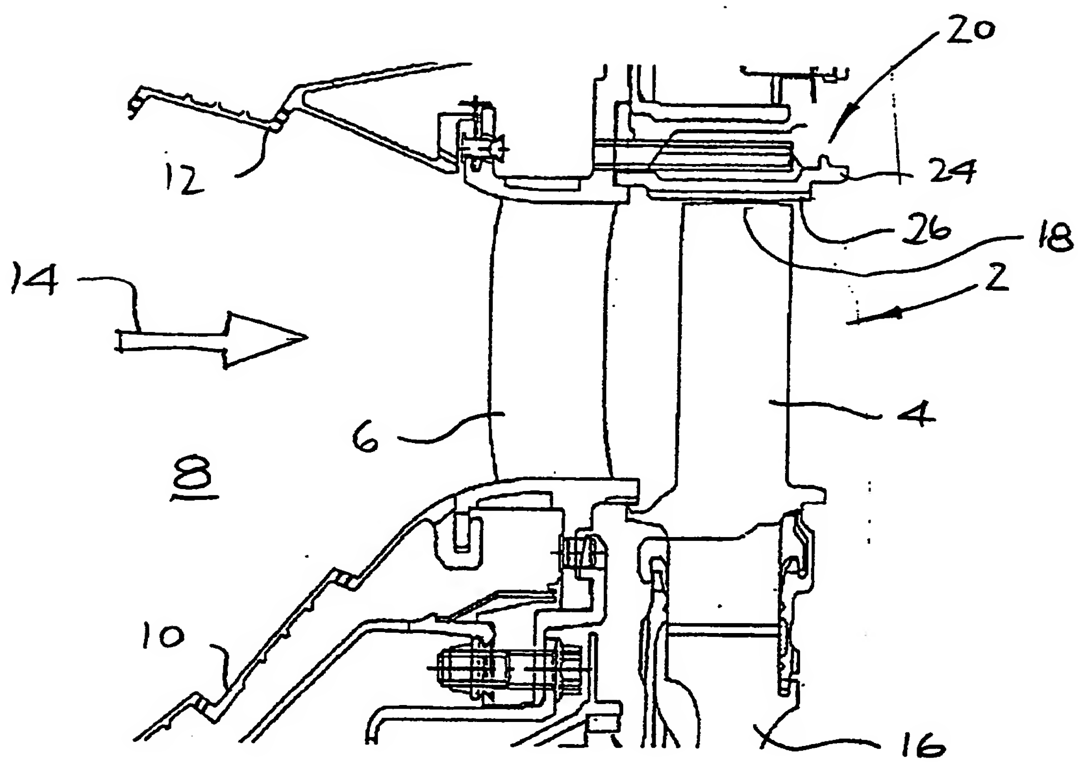
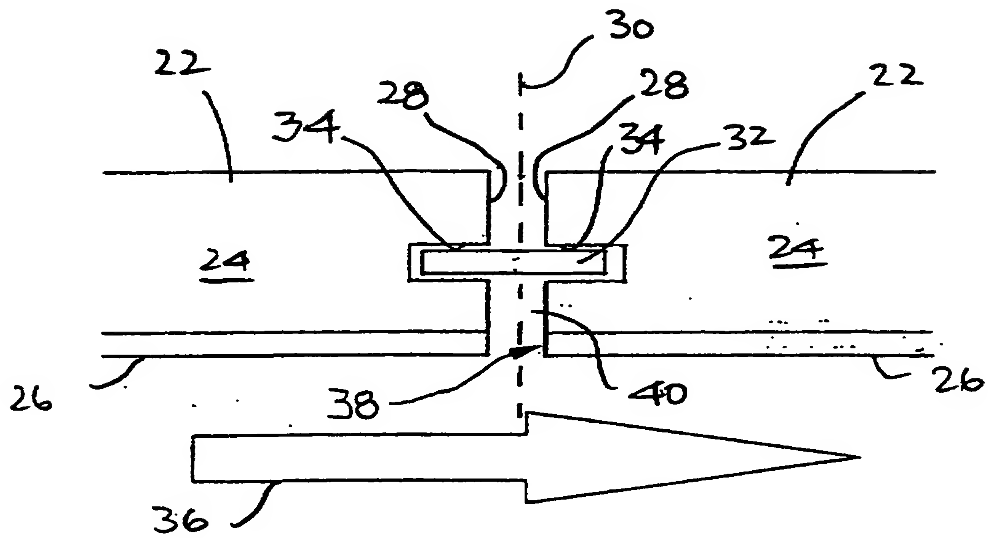


FIG. 1


30
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32
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26
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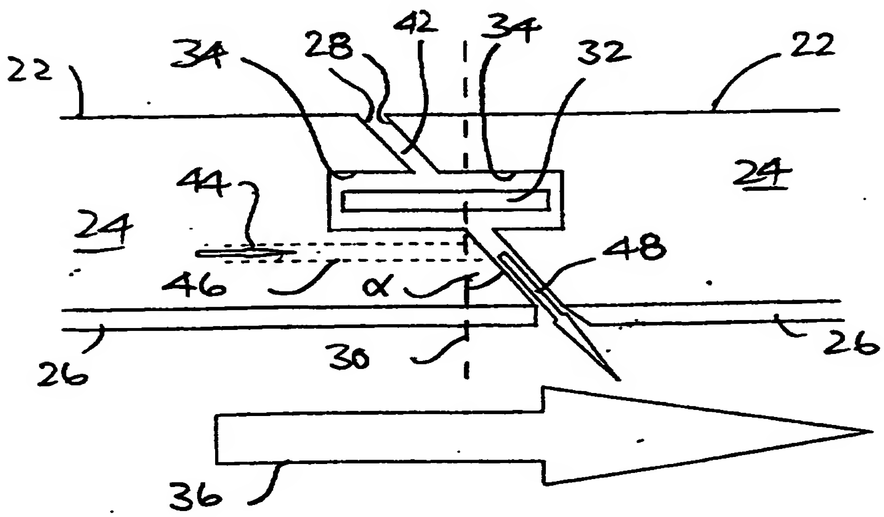
38
36

FIG. 2


34
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42
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32
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22
44
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48
46
α
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36

FIG. 3

GAS TURBINE ENGINES

This invention relates to gas turbine engines, and more specifically to such an engine having a shroudless turbine stage.

In a shroudless turbine stage, the turbine blades rotate within a static liner structure which defines the gas flow path through the turbine stage.

In known gas turbine engines with a shroudless turbine stage, the liner structure comprises a ring of liner segments supported by the turbine casing. In the known liner structures, the opposing end faces of adjacent liner segments extend transversely of the respective liner segments. In other words, the gap between each two adjacent liner segments is aligned with a plane which contains the axis of the turbine stage.

It is common for each liner segment to comprise a substrate of high temperature resistant alloy which has, on its inner surface (i.e. the surface exposed to the gas flow through the turbine stage) a ceramic coatings to provide a thermal barrier. It has been found that the ceramic coating tends to delaminate or spall. This damage initiates at the upstream edges of the liner segments, i.e. the edges which face the swirl component of the gas flow through the turbine stage. Also, it has been found that the substrate material of the liner segments has a tendency to over-heat and subsequently to burn, and this effect is again more pronounced at the liner segment end faces which face the swirl component of the gas flow.

According to the present invention there is provided a gas turbine engine having a turbine stage which is surrounded by a liner structure comprising a plurality of liner segments distributed around the turbine stage and lying adjacent one another, adjacent liner segments being separated from each other by a gap

which opens at the inside of the liner structure in a direction having a component parallel to the swirl component of gas flow through the turbine in normal operation of the engine.

In operation of a gas turbine engine constructed in accordance with the present invention, the gas flow through the turbine stage draws air through the gaps between adjacent liner segments. This flow of air shields the upstream-facing edges of the liner segments from the hot gas flow, and so reduces over-heating of the ceramic coating and the substrate, prolonging the operational life of the liner structure.

In a preferred embodiment, sealing means is provided between adjacent liner segments in order to restrict air flow from outside the liner structure into the turbine stage. The sealing means in each gap may comprise a seal strip accommodated in grooves formed in the end faces of the adjacent liner segments.

A cooling air feed may be provided for supplying cooling air into the gap between each two adjacent liner segments. Where sealing means is provided, the cooling air feed may open into the gap on the side of the sealing means nearer the inner face of the liner structure.

While it may be sufficient for only the region of the gap adjacent the inner surface of the liner structure to extend in a direction having a component parallel to the swirl component of the gas flow through the turbine stage, it is preferable for the gap to be oriented in this manner over its entire extent. This enables the transverse width of the gap to be reduced, while maintaining a sufficient circumferential distance between adjacent liner segments to avoid face-to-face engagement between the liner segments. This condition is known as "chocking" and can lead to undesirable stresses in, and deformation of, the components of the liner structure. For example, chocking may lead to

lack of circularly of the liner structure, causing tip clearance problems.

The gap, or at least the region of the gap adjacent the inner surface of the liner structure, may be inclined at any suitable angle to a radial plane passing through the gap and containing the engine axis. In general, the angle of inclination should be as large as possible, and thus is preferably not less than 10° and more preferably is not less than 40°.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a partial sectional view showing a turbine stage of a gas turbine engine;

Figure 2 is a diagrammatic radial cross-sectional view of a known liner structure for the turbine of Figure 1; and

Figure 3 corresponds to Figure 2 but shows a liner structure in accordance with the present invention.

Figure 1 shows a high pressure turbine stage 2 comprising turbine blades 4 and nozzle guide vanes 6, only one of each being visible in the drawing. The turbine stage 2 is downstream of a combustor 8, having radially inner and outer walls 10 and 12, respectively. The direction of gas flow through the combustor 8 and the turbine stage 2 is indicated by an arrow 14.

The nozzle guide vanes 6 are stationary within the engine, but the turbine blades 4 are mounted on a hub 16 which rotates about the engine axis. The tip 18 of each blade 4 rotates with nominal clearance within a liner structure 18, which comprises a ring of liner segments 20 (see Figures 2 to 4). Each liner segment 22 comprises an alloy substrate 24 to which is applied a ceramic coating 26.

Figure 2 shows the relationship between two adjacent liner segments 22 in a known engine. The end

faces 28 of the liner segments 22 extend transversely of the liner segments 22 themselves, and consequently define a gap which lies parallel to a plane 30 which passes through the gap and contains the engine axis.

Sealing means in the form of a strip seal 32 is provided between each two adjacent liner segments 22. The seal 32 is accommodated in grooves 34 formed in the end faces 28.

An arrow 36 represents the direction of the swirl component of the gas flow through the turbine stage 2. With the configuration shown in Figure 2 of the end faces 28, the swirl component of gas flow is brought to a standstill at a region indicated at 38 by impingement of the gas flow against that end face 28 which faces the flow. Also, inadequate flow across the seal strip 32 means that air in the region 40 is substantially stagnant, with the result that the liner structure adjacent the region 40 is subjected to the static temperature of the gas flow. The consequence of this is that the substrate 24 and the ceramic coating 26 of the liner segment 22 in the region 38 reach very high temperatures. Consequently, the substrate 24 may burn and the ceramic coating 26 may delaminate or spall.

Figure 3 represents a liner structure in accordance with the present invention. In this liner structure, the end faces 28 of the liner segments 24 extend obliquely so that the gap 42 formed between them is inclined to the plane 30 which extends radially of the turbine stage and contains the engine axis. The direction of inclination is such that, in the direction from the outside of the liner structure to the inside, the gap 42 has a direction component which is parallel to the swirl component of the gas flow within the turbine stage, represented by the arrow 36. The angle between the gap 42 and the plane 30 (represented as α in Figure 3) is 40° in the embodiment shown .

In the embodiment represented in Figure 3, a

cooling air feed 44 is shown. The cooling air feed may be drawn from the compressor stages of the engine, or even from the bypass flow, and is supplied through a duct 46 through the gap 42 at a position between the sealing strip 32 and the inner surface of the liner structure.

In operation, the swirl component 36 of the gas flow through the turbine stage draws air through the gap 42, as a result of an inevitable small amount of leakage past the seal strip 32. Additional air flows through the downstream part of the gap 42 by way of the cooling air feed 44. The flow rate through the air feed 44 is controlled by the flow cross-section of the passageway providing the feed 44, and is substantially greater than the leakage past the seal strip 32. The resulting air flow, represented by an arrow 48, provides a film of cooler air over the downstream liner segment 22 (with respect to the direction 36 of the swirl component of the gas flow) preventing direct impingement of the hot gas flow on the downstream liner segment. Thus, the static component of temperature on the exposed face 28 is reduced, avoiding damage to the liner segment and early failure of the ceramic coating 26.

In addition, the inclined orientation of the gap 42 means that the width of the gap 42, measured in a direction perpendicular to the end faces 28, can be reduced while maintaining adequate spacing between the liner segments 22 in the circumferential direction. Thus, the volume air flow required to vent the gap 42 can be reduced while maintaining the spacing between the liner segments sufficiently large to avoid chocking.

CLAIMS

1. A gas turbine engine having a turbine stage which is surrounded by a liner structure comprising a plurality of liner segments distributed around the turbine stage and lying adjacent one another, adjacent liner segments being separated from each other by a gap which opens at the inside of the liner structure in a direction having a component parallel to the swirl component of gas flow through the turbine in normal operation of the engine.

2. A gas turbine engine as claimed in claim 1, in which sealing means is provided for restricting flow through the gap between each two liner segments.

3. A gas turbine engine as claimed in claim 2, in which the sealing means for each gap comprises a seal strip accommodated in grooves formed in end faces of the adjacent liner segments.

4. A gas turbine engine as claimed in any one of the preceding claims, in which an inlet is provided within the gap for admitting cooling air into the gap.

5. A gas turbine engine as claimed in claim 4, when appendant to claim 2 or 3, in which the cooling air inlet is provided between the sealing means and the inner surface of the liner structure.

6. A gas turbine engine as claimed in any one of the preceding claims, in which the gap extends in a direction having a component parallel to the swirl component of gas flow through the turbine over the full extent of the gap.

7. A gas turbine engine as claimed in any one of the preceding claims, in which the gap is inclined to a radial plane which passes through the gap and contains the engine axis at an angle which is not less than 20° and not more than 70°.

8. A gas turbine engine as claimed in any one of the preceding claims, in which each liner segment

comprises an alloy substrate having a ceramic coating on its inner surface.

9. A gas turbine engine including a liner structure which is substantially as described herein with reference to, and as shown in, Figure 3 of the accompanying drawings.

Application No: GB 9925976.4
Claims searched: 1-8

Examiner: Terence Newhouse
Date of search: 28 April 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F1T(TFDE,TFEA)

Int Cl (Ed.7): F01D 9/04 11/00 11/08 11/14 11/16 11/20 11/22 11/24 25/08 25/14 25/24 25/26

Other: ONLINE: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2240822 A	(GENERAL ELECTRIC), see particularly last paragraph on page 10 and fig 4 noting gap 50 which opens inside liner structure	1,2,6
X	US 5374161	(UNITED TECHNOLOGIES), see particularly col 1 lines 45-50 and figs 1,2 & 5	1-8

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.